Dendrochronology of oaken objects – another method.

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Abstract

Dendrochronology methods used in dating human artefacts in the art field are hampered by the presence of many variable and sometimes unknown factors. These lead to hypotheses and estimates of execution dates and tree ages, making the method less accurate. We set up a simple method to better qualify and quantify these factors. We conceived a simulation template. On this template, we localized exactly the saw of an oak specimen in a tree trunk. From this information, we could derive the number of missing tree-rings. It also led us to establish more precisely tree age, tree felling date, and execution date of an artefact. We used a portable digital microscope for very precise measurements of tree-ring widths. This tool could be used in situ or on photographic samples taken in situ. The results were sufficiently accurate to make several observations possible without complex computations or statistical analyses. The method is simple and reproducible in every lab. As study objects, we used a 16th c. Flemish panel painting and 17th c. Flemish furniture.

Keywords: dendrochronology, European oak, panels 16th c., furniture 17th c., methodology, simulation template.

Introduction

Determining the age of wooden panels used by fine painters in the past by means of dendrochronology is still subject to uncertainties. These derive from several unknown factors. First, those derived from the specimen itself. How many heartwood tree-rings (or year-rings) are missing from the outward side of the board to the sapwood? How many sapwood-rings are missing? How many heartwood rings are missing from the inward side to the pith? Secondly, from which tree did the panel derive? Where did it grow, and what were the environmental conditions? How was the panel cut out from the tree trunk?

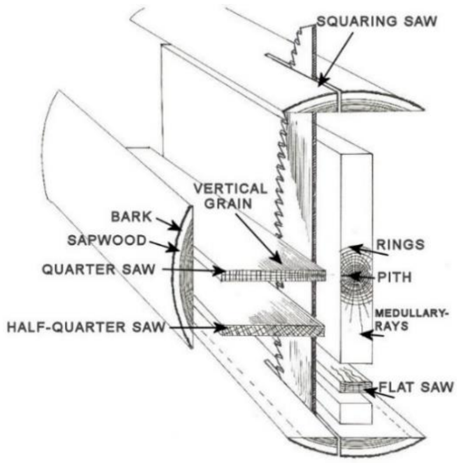

Fig. 1. Quartered oak (see McInnes,R., 2015)

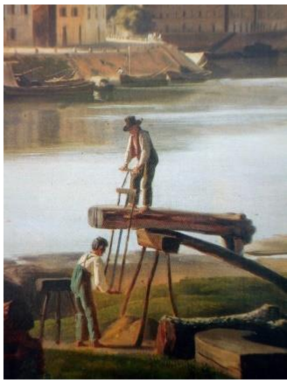

Fig. 2. Sawing a log along the river. France, 1820 .

We conceived a method trying to refine tree dating and execution dating, using a simulation template. As study object, we used an old oak panel painting, style-critically attributed to a Southern-Netherlands' painter from the beginning of the 16th c. in a typical Mannerist style. Another non-related object was ancient furniture, style-critically 17th c.

Materials and Methods

Oak panel painting

The panel measured 72,5 cm x 32,0 cm, and consisted of a larger board 72,5 x 24,4/25,0 cm, and to the right a smaller one 72,5 x 7,6/7,0 cm, joined together with an irregular bevelled joint. The main board was

1,1 cm thick, decreasing in the smaller piece to 0,8 cm. The width of an ancient oak board was normally limited by the thickness of the tree-trunk and hence by the age of the tree, as they are related. We noticed that the structure of the wood continued from the large board into the small one. It appeared that the smaller piece had broken off from the main board, and glued together in the past. Our method could then be applied to the whole width of the specimen. We started off with the assumption that the oak was of Baltic origin. Most of the Low Countries' panel paintings at the time were (Haneca, et al.,2005; Fraiture, 2009; Verougstraete, 2015). We also started off with the acceptance that the board was sawn (Fig. 1, McInnis, 2015; Fig. 2). The backside did not show signs of woodworking.

1. Sample preparation

A specimen is properly prepared. A transversal cut (i.e. right angled or vertical to the grain) (Fig. 3) is obtained in such a way that the medullary rays and the growth rings (tree rings) become clearly visible. The cut of our panel was already completely straight, which facilitated a good preparation.

Fig. 3. Panel transversal cut: unprepared lower border.

Fig. 4. Lower border of the panel after preparation, including the 7-cm annex to the right.

A macro photograph of such a transversal cut is then made together with a mm scale (Fig. 4). By means of a photoshop computer program (PaintShop ProX7 -64 from Corel), the slight warping of the panel due to nature/moisture can be undone. The advantage of a photo resides in the possibility for other researchers to reproduce the results without moving the often very precious panels, as well in the present as in the future. See the considerations by Baillie (2002).

This photograph is then printed on an A4 high quality paper, together with its scale. The program Microsoft Office Picture Manager makes the photo fit in different dimensions. The size of the best readability is chosen. This photo print is then cut out of the sheet of paper, together with the scale, because the scale varies with every specimen and every print. The scale of the photo is preferably close to a regular mm ruler.

2. The simulation template.

Locating the precise original position of the board in the tree trunk in connection to the pith, is, in our opinion, a necessity. To do so, we conceived a "**simulation template"**.

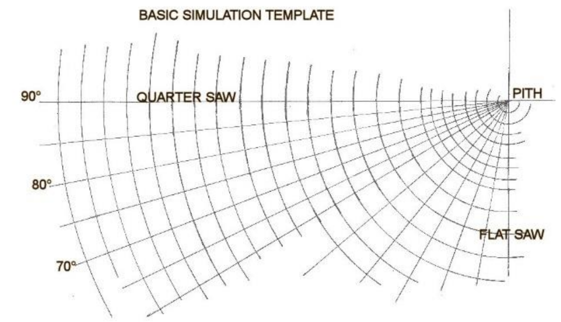

Fig. 5. The basic simulation template, left lower quarter

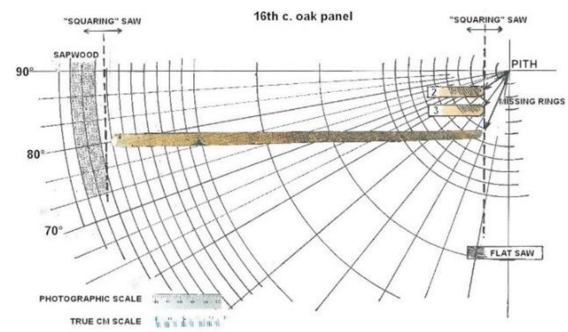

Fig. 6. Application of the panel painting's transversal cut on the template.

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A basic simulation template is drawn on A3 drawing paper with pen and black ink. Or a pre-printed paper Is used. This basic drawing simulates a virtual quarter of a tree trunk's transversal cut, from the pith to the bark. The width of the drawing is larger than the sample to be analysed. In this way, for instance, a lower left quarter is prepared (Fig. 5). The horizontal radius is represented by the X-axis. On this radius, every cm or every 5 cm (<u>using the scale of the sample to be used</u>) a mark is put from the pith to the other side. From these marks, a quarter circle line is drawn (above or under the horizontal radius, as far as needed), representing virtual tree-rings. Then, every 10 degrees a radius is drawn from the centre (pith) to the periphery for about 50 degrees, and further subdivided as needed for a good reading. These radii represent virtual medullary rays.

The cut-out photographic sample, is then placed on top of the basic template, with its medullary rays converging to the pith. This sample is then moved slowly in two directions: up and down and left and right until its medullary rays and its tree-rings closely match the virtual rays and rings drawn on the template. This can better be done under a magnifying-glass. Only one position (in a tree trunk quarter) fits both virtual radials and rings. Fig. 6 shows the position of our sample on the template. The closer the match, the more precise the results.

In this way, we find the **exact original location** of a board in a tree trunk quarter, and its position in relation to the pith. It proved that our panel was a “half-quarter saw”. A full quarter sawn board would be less easy to match, as only the curvature of the rings – of no more than the thickness of the panel – must match, the medullary rays being almost parallel to the horizontal radius. A discussion point may be the fact that the tree rays and rings are graphically not 100% exact, due to the many factors influencing the wood during and after its life. But this did not influence our methodology. We foresee graphical computer programs, that would find the best fitting position on a digital simulation template.

At the inward side of the sample, our method provided us with more information.
First, we noticed how far the original ‘vertical’ squaring cut (Fig. 6) is removed from the vertical line dividing the pith, which gives us an idea on how the sawing happened. Indeed, the sawyer had to stay away from this centre line to avoid the pith, which has undesirable physical properties. In some cases, some wood at that side may have been lost as well.
Secondly, the most important observation: we could now **measure exactly the radial distance** from the inward border of the sample to the pith. This measurement must be made in mm on the same scale as the photograph*.* Multiplying this distance by the mean per cm of all the counted rings (or a sequence of representative rings) gives us the **number of missing tree-ring years at the pith side**. This number should be added to the counted heartwood rings visible in the specimen. In Fig. 6, the distance of a fictive board no. 2 is less mm (or tree rings) away from the pith than the distance of the fictive board no. 3, and less than our sample, yielding per position less missing rings.

Fig. 7. Original tongue-and-groove border.

At the outward side of the sample, the template permitted us to delineate **the virtual limit of the heartwood and the start of the sapwood** (Fig. 6). The presence in our panel of an original tongue-and-groove border (Fig. 7) for adhering a small additional piece of panel (now missing) suggests that the sapwood border had been reached. Some heartwood rings may also have been lost, but mainly for economic reasons their number may have been limited. In fictive boards nos. 2 and 3 on the template, (Fig. 6) some more heartwood rings would have been lost at the sapwood side by the square sawing which removed the bark and the sapwood.

Many times, there is no clue, whether the heartwood limit is reached. Only the presence of sapwood at the border of a board defines this limit. Our template method however gives indications. Anyway, to determine the age of a tree, a certain number of sapwood rings must be added to the total of visible heartwood rings counted. Exactly how many is a point of discussion (Fletcher, 1974, p. 252; Haneca, 2005, p.28; Fraiture 2011, p. 9.). The study by Sohar (2012) defines in our opinion best the number of sapwood rings in oak, in relation to its provenance. From this study, we took over an arbitrary median of 11 rings.

3. Measuring tree-ring width

To determine the period in which the tree grew (tree dating), one must measure every individual tree-ring width, plot this measurement series on a curve - chronology curve -, and synchronise this curve with known dates.

Digital photography and measurement of ring width directly on the computer screen was done by Fraiture (2011). We can measure digitally directly on top of the element, but we found this cumbersome and delicate, We preferred to measure on a photographic sample, printed out on A4 high quality paper, together with its mm scale.

For measuring individual ring width, we used a FireflyPro GT 700 digital microscope (Firefly Global, 464, Common street, Suite 281, Belmont, MA. 478, U.S.A.), which has a built-in measuring program, with a precision of one thousand of a mm. The need for such a high precision reading is relative, as tree-ring boundaries are irregular, and measuring depends also on the appreciation by the researcher, certainly for the very small rings, less than 0,5 mm. In addition, other variables are present, due to the nature of the once living object, influencing absolute precision. One of the advantages of this tool lies in the possibility to control the resolution of the sample: too high a resolution visualizes the irregular cellular level, influencing clear delineation of boundaries, too low results in a more difficult measuring.

Another advantage: one can measure in the lab, away from the object. More precise results can be obtained by repeated measuring, at a different location in the sample, or by different researchers. But for our study, measuring once was sufficient. Several researchers have suggested methods to improve measuring precision using sophisticated means, which facilitated their large data statistical analysis. Hietz (2011) published computer programs for measuring and analysing tree-rings in tropical wood using Excel, R and Sigma Scan.

The photographic sample was fixed on a sliding table under the microscope. Calibration was performed on each section to avoid eventual distortion errors. Because of the oblique position of the rays and of the rings in the sample, we measured stepwise following the direction of the medullary rays, along a longitudinal line.

All our data were entered in a Microsoft Excel 2016 for Windows 10 program (Microsoft Corporation, Redmond, Wa., U.S.A.). In our sample, we plotted tree-ring width against calendar years. Fig. 8, shows the tree growth activity in a long period. This activity is accepted to be influenced amongst others by environmental conditions: wide rings equal good growth, small rings poor growth.

To easier situate the curve in a period, we gave temporarily the last measured heartwood ring the prospective date of 1520, which was the art-critical date. Thereafter, an adjustment was made, because the curve showed well defined event and pointer years (Haneca 2005), also called indicator years and signatures (Fletcher 1977). We used 1303 as most prominent event year (poor growth), as well as other indicator years as published by Fletcher and Haneca. In our curve, a period of poor tree development (mean ring width of 0,49 mm) started in 1301 and lasted till 1320. This could read as a signature for a ‘cold’ period. A ‘warm’ period lasted from 1372 till 1396 (mean ring width of 1,96 mm). Crossdating with existing master base chronologies is difficult without knowing the exact origin of this tree. Dendro-provenancing, however, does not lay in the scope of this work.

Applying our method, we arrived at the following results. Our specimen had 238 heartwood rings with a mean width of 1,14 mm yielding 8,8 rings per cm. On our template, the radial distance sample-end to pith was 52 (photographic) mm. Hence, 5,2 cm x 8,8 or 46 rings to the pith were missing. We added these directly into the chronology curve (as a straight line, see Fig. 8). Estimating missing rings is hazardous, and many times the source of speculation. But we could calculate them and the number is not insignificant: 19% of the total counted. Taking the mean number per cm of all the counted rings may give a small aberration, as ring-width may vary. We could calculate the tree age as follows: 238 heartwood rings counted, 46 calculated missing rings to the pith, a few missing heartwood rings (arbitrarily 2) at the outward side and an estimate 11 missing sapwood rings (Sohar, 2012)), gives us a total of 297 tree-ring years, this being the age of the tree at the time it was felled. Baltic oak trees of three, four or more hundred years have been used in the past.

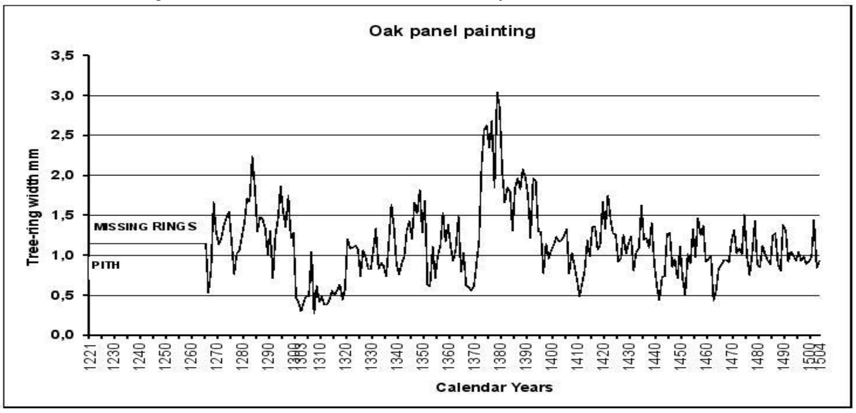

Fig. 8. Chronology curve oak panel painting.

Using 1303 as pointer year in our chronology curve, gave us 1221 as first living year, and 1504 as last measured heartwood ring year. The year 1504 would then be the *terminus post quem* for the execution of our painting. We also had a *terminus ante quem:* 1524. Indeed, this was the year one of the proposed co-painters died. These dates left us with an interval of 20 years, to account for the total number of missing sapwood rings, and the period of transport, seasoning, stockpiling and execution. For these, different values and opinions have been used. Forwarding a median of 11 missing sapwood rings, -arbitrarily- 2 missing heartwood rings at the sapwood side, 5 years seasoning and 1 year execution, we arrive at 1523 for the execution of the painting. This is close to the proposed art-critical date and conform the Mannerist style period, wherein this Antwerp artist was said to be active (1509-1527).

We propose the template method as a suitable dendrochronology tool. With this method, it is possible to precisely **locate the original sawing position of the specimen** in the log and to determine the nature of the sawing. If needed, the position of related boards can easily be traced on the same template. From its position on the template, it is possible **to calculate missing rings at the pith side, and estimate missing rings at the sapwood side**. The number of missing rings differs with the original sawing of the plank and its location, quarter cut, half-quarter cut, or in between. In a full quarter cut, which follows the horizontal line or axis in a simulation template, fewer rings are lost at the pith side. But a half-quarter cut stops further away, and a larger number of rings are lost in the total counting. Hence, a better dating is obtained as well for the tree age, as for the execution date. In the past, panel sawing rarely included the pith. Original cutting was subject to different craft considerations and demands, and was performed in specialized factory's. From the template, we deduced that **a vertical squaring cut** (Fig. 1, Fig. 2) was performed to avoid a flat-sawn end, which is not fit for panel use (flat surface, flat grain and poor adhesion, warping, shrinkage, splitting). With the template, **the sapwood location** can be approximated. Also at that side, a small number of missing heartwood rings, could be supposed depending on the location of the plank and its relation to the sapwood's inner border.

To demonstrate our method on different objects we used furniture.

Ancient oak cabinet

Fig. 9. Prepared transversal cut of oak plank with pith

Fig.10. Oak plank, detail: pith.

We studied an isolated oak plank from an (alleged) old cabinet, probably originating from its back or bottom. Exceptionally, this element still has its pith, resulting in a lesser quality piece, but interesting to demonstrate our method. The board measured 56,0 x 18,5 x 1,1 cm, was flat on both sides, fine grained except toward the pith side.

On one side was a straight lap, on the other side a tongue-and-groove end. We used the same method as described above. The transversal cut (Fig. 9) showed that the first living years were very propitious for growth as rings are rather wide (detail Fig. 10). Using our template, we could exactly locate the sawing, namely a quarter saw just under the horizontal axis.

Medullary rays and circular rings meet the ones on the template, and the (exceptional) presence of the pith confirms this location (Fig. 11). Taking the pith as ring number 1, we counted 117 tree-rings, with a mean width of 1,52 mm and 6,6 rings per cm.

Our tree was *minimum* 117 + 11 years (sapwood) or 128 years old when it was felled. Visual crossdating with a section (1330-1446) of the panel painting (Fig. 12) gave a complete match and proved that the first growth year was 1330. The unknown factor is the number of rings absent at the outside. The tongue and groove end, which is first seen in the beginning of the 16th c. led us to believe that the tree was much older and our plank half of an original cut. The felling date would then be around 1575 and the execution date end 16th c.

Planks procured by other means than square sawing, such as by splitting, cleaving, or radial sawing, also fit our template on the horizontal radius, as medullary rays run very much parallel to the radius. External inspection of the surface may reveal such production methods. Our method is also valid for such boards.

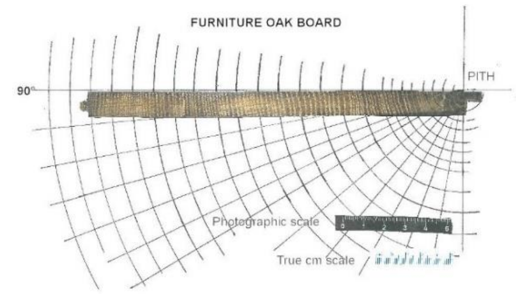

Fig. 11. Template with quarter cut oak plank with pith.

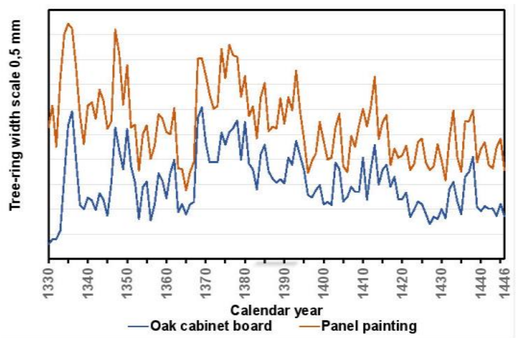

Fig. 12. Crossdate cabinet board and panel painting (period 1330-1446).

Ancient oak cupboard

Dating old European furniture of the 15th, 16th and 17th c. has a definite relevance. Monumental pieces such as four-door cup-boards, were ordered and delivered only to high class people, clergy and noblemen, later also to the rich middle class, at a time when commoners possessed no more than a chest to keep their belongings. Antwerp was an important production centre of furniture. Quality was desired what materials and craft concerned. In the Southern-Netherlands oak was traditionally preferred as material. There also existed a long tradition for the adornments resulting in ever changing styles. Furniture became an artwork in itself. Long lasting devastating troubles in Europe resulted in the loss of many of these. Others were exported abroad, some extensively restored, and others copied in later ages. Hence the relevance of dating.

Obtaining the true date of execution by dendrochronological methods is hampered by the fact that visible elements often do not have large tree-ring sequences. And good elements are not accessible without disassembling or damaging the object. Also, tree sawing for carpentry may have differed from panel board sawing, and dendrochronology methods applicable to panels may not apply to furniture or other artefacts.

Our template method proved to be of value. We analysed three elements of an (allegedly) 17th c. Flemish cupboard (194 x 168 x 60 cm), without disassembling the object. We started with a presumed art-critical date of 1620.

First element: cupboard right door style.

One of its four frontal doors consisted of two sculptured panels held within a heavy wooden frame, like the frames of a painting. One of its two vertical styles measured 74,0 cm x 21,0 cm x 2,5 cm (2,5 cm equals one old Flemish thumb).

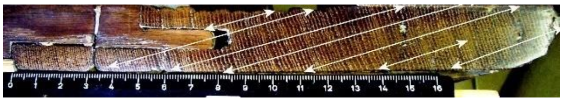

Fig. 13. Prepared transversal cut of cupboard right door style.

This style was fixed by means of a tongue-and-groove joint into the horizontal styles. It was cracked at the inside end (Fig. 13). This style lent itself well to the preparation of a sample 'in situ'. We applied our method. The photographic sample was superimposed on the template. (Fig. 14, A). A reduced scale template had to be used as this large sample **did fit an eccentric location in the quadrant.** It was a lower half-quarter cut board. This position suggests a **mid-cut squaring saw** (on the template indicated by an interrupted vertical line) which could yield twice the number of planks in one half of a large tree trunk (see the three grey virtual planks on the template).

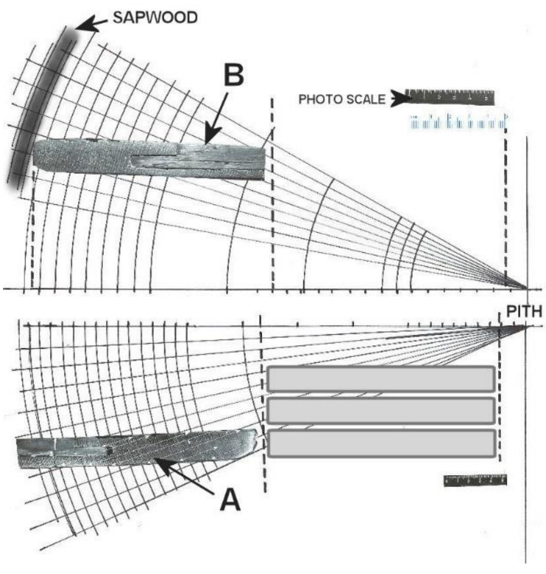

Fig. 14. Combined template with cupboard right door style (A- under), and left door style (B-top) on a different scale

Hence, carpentry board sawing may have differed from panel sawing, influencing dendrochronological conclusions. Measuring of the 180 heartwood rings gave a mean ring width of 1,03 mm and 9,7 rings per cm. This suggests Baltic oak as origin. Toward the pith side we calculated **247 missing rings (**25,5 photographic cm radial distance x 9,7)! Adding the 180 counted rings and 11 missing sapwood rings, we arrived at a tree of at least 438 years old.

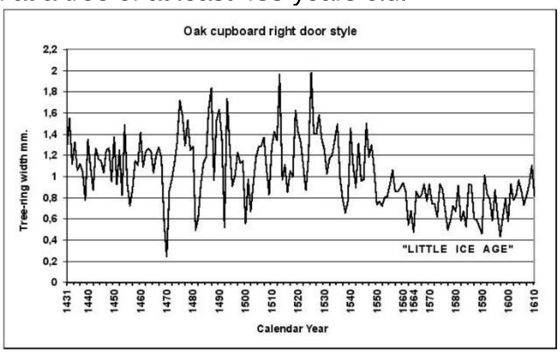

Fig. 15. Chronology curve right door style (cupboard first element).

The 180 ring widths were plotted against calendar years (Fig. 15). We adjusted this curve using the pointer year 1564 (see below). The last measured ring would then fall in the calendar year **1610**.

Second element: cupboard sculpture – 'lion head'.

Another element seemed interesting for analysis 'in situ'. It was one of the typical lion-head sculptures, used as adornment, cut flat at the top, measuring 12,6 cm by 6,0 cm. At one corner, the sapwood was visible, and still showed a few rings. We proceeded as above. A photographic sample taken 'in situ' was placed on the template (Fig. 16). The element was a quarter cut, in a big chunk. We measured 100 heartwood rings with a mean width of 1,35 mm and 7,4 rings per cm, correlating with 'local' oak (Fraiture, 2009).

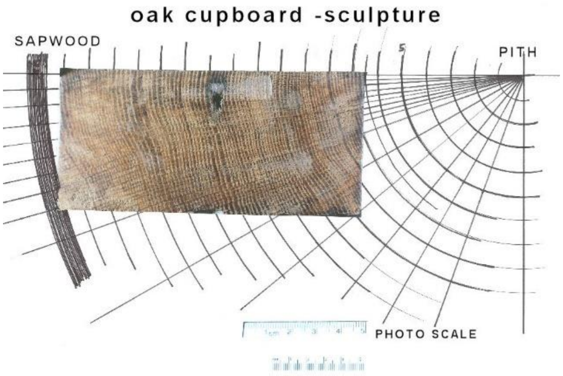

Fig. 16. Template with cupboard sculpture sample.

The last counted ring was 6,5 cm away from the pith. Hence, we calculated 48 missing rings (6,5 cm x 7,4). Adding sapwood rings (3 visible + 8 missing) this tree would have been 159 years old before it was felled. In the chronology curve (Fig. 17), we included the missing rings at the pith side as a straight line. Adjusting the curve for pointer year 1564 (see below), we obtained 1626 for the last heartwood ring measured.

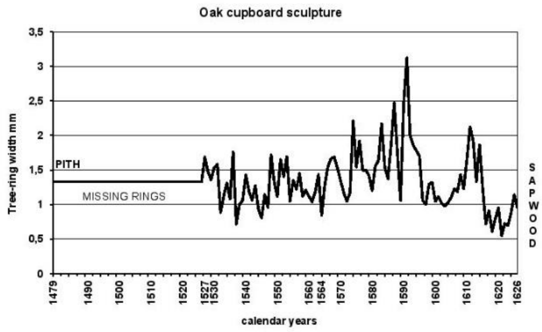

Fig. 17. Chronology curve sculpture (cupboard second element).

One of the side questions was to see whether there was a time (execution) match between the oak the sculptor used and the oak (first element) the joiner used. At first sight there seemed to be no correlation. Hence a third element was analysed.

<u>Third element: cupboard left door style.</u>

The left door was assembled in the same way as the right. As specimen, we used a vertical style, which was 74,0 cm x 13,0 cm x 2,5 cm. We proceeded as above. A photographic sample taken 'in situ' was placed on the template (Fig. 14, B). This sample was located in the virtual <u>upper</u> quarter of a tree trunk. We measured 91 heartwood rings, with a mean width of 1,44 mm and 7,0 rings per cm suggesting again another (local) oak source. The last heartwood ring was 18,0 cm away from the pith. This gives a total of 18,0 cm x 7,0 or 126 missing rings! Three sapwood rings were visible at the outward border. The tree was then 91 + 126 + 3 + 8 (missing sapwood rings) or 228 years old. The chronology curve is in Fig.18, the missing rings as a straight line. Adjusted for pointer year 1564 (see below), the last measured heartwood ring was also 1626.

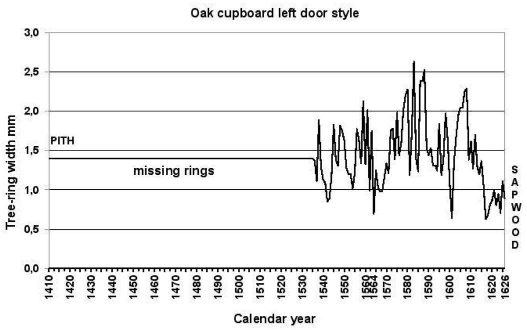

Fig. 18. Chronology curve left door style (cupboard third element).

- ✓ *Crossdating.*

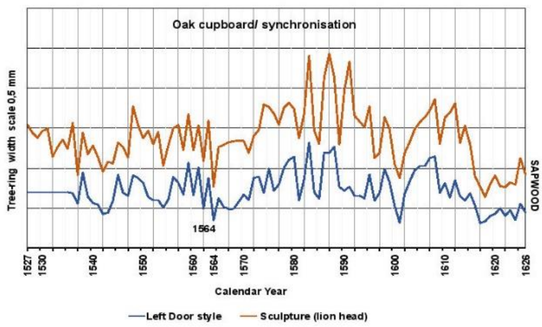

Fig. 19. Crossdate sculpture and left door style (period 1527-1626).

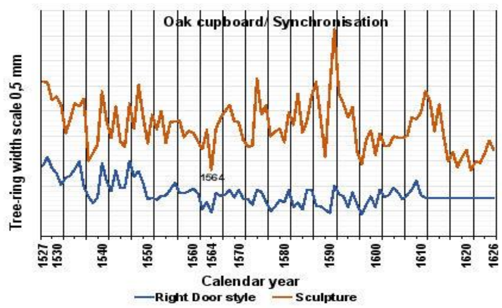

Fig. 20. Crossdate sculpture and right door style.

By visual crossdating the chronology curves of the sculpture (local oak) and the left door style (local oak), we obtained a good match (Fig. 19) even when the elements were from different trees. The date of 1626 as last ring measured in both was confirmed.

We also crossdated the curves of the sculpture (local oak) with a section (1527-1626) of the right door style (Baltic oak). There was a good visual match (Fig. 20) even when the mean ring width of the style in that section was very small (mean 0,88 mm). However, between the last measured ring of each sample there was a gap of 16 years (visualised by a straight line in the style curve). This interval could represent wood loss, and/or seasoning/ stockpiling time for the Baltic oak, which lasted sometimes up to twenty years. The joiner probably used this wood out of stock. The stronger wood intended for solid structural parts, the softer and more recently felled wood for adornments and lesser parts.

From these observations, it resulted that the art-critical cupboard execution date of 1620, which we initially presumed, could not be upheld. We obtained an execution date precisely at **1640**: 1626 (last measured ring in two specimens) + 3 (visual sapwood) + 8 (missing sapwood) or 1637 as felling date + 2 seasoning years (for the local wood) + 1 fabrication year.

We conclude that the template method gives more insight in the production process of oaken artefacts and reveals more easily differences in tree provenance, in tree log sawing, in origin of wood elements, in felling dates and execution dates. Dating furniture is hazardous and several elements in one object should be analysed.

- ✓ *Visual synchronisation.*

In visually analysing chronology series, one must consider two forms of representation of the curves in a Microsoft Excel program. One is a '*compressed'* curve, the other an *'extended'* curve.

In a *'compressed'* curve one obtains a visual impression on longer periods of tree activity (signatures) using long tree-ring series, for instance, in the panel painting (Fig. 8) and in the cupboard first element (Fig. 15). In the latter, we notice from 1473 to1549 a period with fair environmental conditions. Thereafter follows a long period of depressed growth. It starts rather abruptly in 1550 and reaches its first deep points in 1562, 1563, and **1564.** These years are 'event' years (Haneca, 2005). In this example, they are correlated with historical descriptions of extreme cold winters with hardship for the people and severe economic repercussions in the Low-Lands (Van Oesbroeck,1565, p. 97-102) and maybe in all Northern Europe. They also started an '*event period'* called "*Little Ice Age*", (see www.wikipedia.org), - mean ring width **of 0,77 mm** -, which lasted till the 17th c. These observations allowed us to adjust our initial chronology curve with the prospective execution date of 1620, using the historic 'annus horribilis' of 1564 as pointer year.

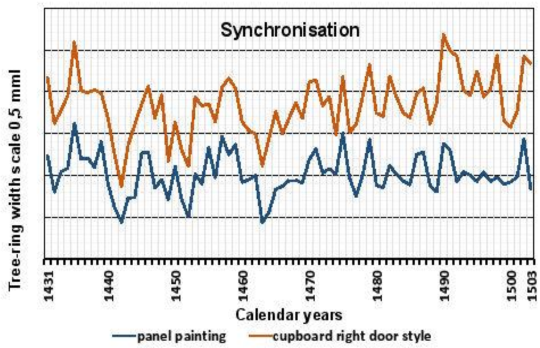

Fig. 21. Overlap part (1431-1503) of chronology series of panel painting and cupboard.

We used *"extended"* curves for precise **visual crossdating** samples of the same object**,** such as in Figs. 19, 20. They were also used for crossdating samples from different objects, such as in Fig. 12.

We also **overlapped** a section (1431 - 1503) of the panel painting's adjusted curve with the same section of the cupboard's right door style adjusted curve (see Fig. 21). The visual match was complete, without any shift in time. On that extended scale, pointer years were well detectable, even when the average ring width for that period was only 0.83 mm for the cupboard element and 1,01 mm for the panel. And even when the trees had a different provenance, and the artefacts were from a different nature and from a different period.

Discussion and conclusion

In using dendrochronology as a means for dating oak trees and oaken artefacts, we propose a different approach. Locating samples on a template gives more insight in log sawing. From there, we could derive that estimating missing tree rings and dating is hazardous and may result in large errors. Using this simulation template one can obtain more precise execution dates of artefacts, as well as tree ages. Also, the diameter and circumference of trees can be derived. Different specimens in one object can better be compared and objectivated. Measuring tree rings by means of a portable digital microscope, is practical and precise. It provided us with accurate short-term and long-term information on tree growth. Our method is a simple working instrument, that can be used in a lab in the absence of the study object. It can be used without computations nor statistical analyses. The method can be performed and reproduced in any other lab at any time, and is applicable for ancient oak, with slow growth. The method however does not replace other existing crossmatching, statistical analytical, and provenancing means, if so needed for further certification of the obtained results. The method could also be further digitalized. Many conjectural conclusions could be made from this study but they are beyond our scope.

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